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Evening Discussion: Research Projects, Collaborations and Career Aspects

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Abstract. Do I need to be a genius to become a good scientist? How can I collect the experience I need to do research? What do I do if I made a mistake? How can I find a useful research project? How do I know that it is of good international scientific standard? How can I judge that it can be realistically carried out? How can I structure it? Should I collaborate? Who should I collaborate with? Who do I better avoid? How far can I be guided by others? How do I know whose opinions to trust? When should I be sceptical about what other scientists say? How can I plan my career? Can I plan it at all? What do I need to take into account if I am determined to work as an astronomer for the rest of my life?

All these questions (and more) are of concern for the young scientist trying to find her/his place in the astronomical community. While there is no standard solution for any of these problems, I would like to present some basic helpful ideas and concepts that were mentioned during this evening discussion.

1. Introduction

At the beginning of a scientific career, it often seems difficult to find the best place for oneself in the community. It appears full of colleagues who are much more experienced than you which may sometimes even be discouraging. Of course, all established scientists were in the same situation before, and they have found their way.

In the following, I will try to give some suggestions that can help you to become a successful astronomer. Unfortunately, there is no definite way how to achieve this goal, but common sense is certainly a major ingredient. All the recommendations below are based on common sense (I hope).

If you are interested to get a more detailed view on the problems a young scientist may encounter, and how to master them I can warmly recommend the book by Medawar (1979) to you. In fact, I believe this book should be basic reading for every scientist (young or not), and I have adapted several suggestions from it for the present article. Most of the discussions below come however from my own experience, still being a young scientist myself (again: I hope). This is supplemented by some comments that were made during the evening discussion summarised here.

Before getting started, I should also point out that my views are of course influenced from the scientific environment I grew up in, namely the Western European one. I understand that the problems of people from countries to the East of Austria may be different, but I do not have the experience to discuss these and I want to apologise for that.

2. Gaining experience

At this conference, you have met several people who are well-established scientists and who have collected a lot of experience over the years. You may ask yourself how one can build up this experience and how to use it efficiently.

2.1. Initiative

In my opinion, the most important part of the character of a good scientist is not genius; it is self-initiative, common sense, enthusiasm and a strong will to work hard. A curious, critical and enquiring mind is extremely important in the quest for answers to unsolved questions, which is what science is about. Therefore it is important, even as a young student, to go and search for these answers and not to wait that someone else gives them to you. We are no longer in school.

One of the most important pieces of advice I ever got was: go figure. Or, the British version: use your intelligence. The message is: try to find your solution instead of asking questions that you can actually solve by yourself. In a career as a scientific researcher, you will have to solve problems nobody solved before. Therefore it is important for you to know how problems are tackled most efficiently, because nobody will be able to solve the problem for you. Doing that will be your job.

2.2. Reading

One way to find out how scientific problems can be solved is to see how others answered scientific questions, what strategies they used and to what results this lead. This information can be found in the literature. There is a lot of literature around, and there are electronic means to find what you need very efficiently. For instance, the ADS Abstract Service[1] can be searched not only for authors or objects, but also for title or abstract words or phrases.

The reason why I mention this is that I find it very important to read and know the literature for your field of research. You don't need to know everything by heart, but you should at least have an idea where to look it up. According to my experience, young astronomers often do not know the literature well enough and this is of course a problem if you are to interpret your results or if you are to discuss them with others.

If you want to start working on a topic, it is useful to find good recent review articles. There are special review publications (like the *Annual Review of Astronomy and Astrophysics*) which can be consulted, but it is usually more efficient to look for conference proceedings books (nowadays mostly published in the *ASP Conference Series*) related to your subject and to scan the review articles there.

The advantages of these review articles is that they are written by people who are the leaders in the respective research field, i.e. they will be competent overviews. Review articles also contain a large number of references to interesting papers on the subject, and you can pick those that seem most useful to you

[1] http://adsabs.harvard.edu/abstract_service.html

for further study. These again will contain references that will be of use. In this way you can start to explore your field by yourself.

Reading, of course, is not the only way to build up experience and you should not spend all your time reading. You should not forget to work on your own research as well. You can begin simply by just trying to reproduce results from the literature. Observers may request published data from colleagues, whereas theorists may be able to get other people's codes. Experience is gained best by trial and error. This way you will get a feeling of which strategies to solve a scientific problem promise more success and which ones may be less favourable. In this way you can also grow self-confidence. It naturally comes with experience.

2.3. Publishing papers

Another way to collect experience is to publish papers. As young scientists may initially not be so well known in the community, their promise (and thus often their probability to get a job) will, to a large extent, be measured by means of their publication list. On the other hand, it is natural for a student to want to graduate as soon as possible to move on to a "real" job, to earn "real" money and to be free. Consequently, many people want to get their dissertations done quickly and then write a few papers from this material.

I think this is the wrong strategy, if you want to stay in astronomy. Everyone who applies for a postdoc position necessarily has a PhD, but not everyone has papers. Therefore I suggest that as soon as a given part of the PhD work is finished, the paper should be written and submitted. There are additional advantages on top of having publications to show on your vita, such as that you can use the referee's report for your thesis and to gain experience, and you can learn how to separate a larger piece of work into pieces that can be published, which is an important skill for the future - see below.

The decision about when a work is sufficient for publication as a scientific paper is a subtle one. Some people separate their studies into the largest possible number of MPUs ("Minimum Publishable Units") and try to get through with this strategy. Others write very comprehensive papers, which can become so long and strenuous so that few people would read them. I think that the truth is somewhere in the middle. Read other people's papers and use your intelligence.

2.4. Writing proposals

Dirk Terrell noted during the discussion that having skills to write winning proposals is also highly important. To conduct your research, you will need to acquire money and telescope time (the latter if you are an observer), and you will need to justify the allocation of these resources very well. This requires a certain way to argue your science case.

As a student, you may be able to practise proposal writing. You can offer help to your advisor when proposals are being written. (Some advisers actually *make* you write proposals, like mine did. I did not like the additional work this meant at all, but when we got the money, I was very happy...) The improvement suggestions and referee's reports you get will help you to upgrade your skills and you will be better equipped for the times when you have to write your own applications.

2.5. Making mistakes

Everybody makes mistakes, even the most famous colleagues. When I asked the more senior attendees of this conference, who did not yet publish a paper that contained a mistake, nobody raised a hand (except Conny Aerts, who however expected a different question). And of course, it is only people who work who make mistakes; people who don't, won't.

What would you do if you made a mistake that can no longer be corrected, e.g. if it has already appeared in print? There is no point in covering it up. This is unethical and if someone discovers the cover-up, you will lose credibility and you will get a bad reputation in the community. So, if a mistake happens, admit it and move on. You will get a better name if you are known to be honest.

As your experience grows, you will have a number of ideas to explain certain scientific phenomena, you will have some hypotheses, and some will be your favourites. However, there is one thing you should always keep in mind: the degree by which you are convinced about your hypotheses is totally independent of their correctness. Therefore it is always useful to think critically about one's own ideas. In this respect I would like to let you into a secret. I now tell you who the scientist is I trust least: it is myself.

2.6. Observers versus theorists

At this point, Don Kurtz remarked that this is because I am an observer and that the situation is different for theorists. This reminds me of an incident when I overheard a conversation of an observer (hereinafter referred to as "O"; everyone involved here shall remain nameless) with his student, where a theorist (called "T" in what follows) was also present. The student had presented some results of her dissertation work, showing the comparison of observed light curves and the fit she had computed to them. Everything looked very nice, except for one night, where the light curve and the fit were just mirror images of each other. After some discussion, it turned out that this particular light curve was simply plotted upside down. No big deal.

However, O took this as a starting point to explain the student about carefulness in science, and said, "...and you have to check twice and three times before you publish something and when you print it you have to check it over and over again..." (getting very excited) "...and you can only put something into a paper when you have checked it once again, and I am sure this is also true for theorists, isn't it, T?" And T's answer was, "Mmmm... once we obtain, more or less, good results, we don't check the code anymore."

Of course, T was kidding to remove some of the tension of the situation, but it is often (jokingly) said in astronomy that theorists and observers are heard differently: if an observer says something, everybody believes it except her/himself and if a theorist says something, no-one believes it except her/himself. It is up to you whether or not you believe this statement...

3. Research projects

As Laurent Eyer pointed out during the discussion, it is not necessary to go and find a research project in some cases. These can be pre-defined by the team you are working in (such as large collaborations) and consequently you contribute to the success of the whole team. This is often the easier option, but it may not be as scientifically satisfying as pursuing your own ideas would be.

On the other hand, if you are unsure of what to do, you may also choose to attach yourself to a group where interesting and important work is going on, and where the spirit is good. In that way, you can increase your experience and find your own way through discussions with other group members. Personally, I did a similar thing when I got myself a grant during my PhD student years that allowed me to go overseas to join just such a group. I still benefit from that today.

Most commonly, however, you have to define and carry out your own research projects. This is especially important if you want to obtain a grant to conduct research (and in this respect, often to fund your own salary), but it is also commonly required to outline a research plan if you apply for a job somewhere.

The choice of a good research project can therefore be critical to the advancement of a young researcher's career. Are good projects hard to find? I don't think so, and one only needs to keep a few basic things in mind.

First of all, the problem you are going to work on should matter to the community and be scientifically interesting. For instance, if you were to determine the V magnitudes of all the stars in the *Bright Star Catalogue* to an external precision of ± 0.01 mag, this would certainly be useful to many photometrists, but it won't create a lot of excitement about science because it's boring. However, if you set out to determine the Hubble Constant (or "Hubble's Random Variable" as malicious tongues call it) to the same relative precision and succeed, you will be a hero. In brief, you want to work on a problem where the answers matters.

As a next guideline, you do want to attack problems that are soluble within a certain amount of time. If you are at the beginning of your career, you only have a few years to establish yourself. You will also have to write reports for your grants, give accounts of previous work if you apply for telescope time, etc. etc. Therefore you must take care that you can get results within the limited time available.

Of course, some of the relevant scientific problems you identify may take longer to solve than just a few years. In such a case, it is often possible to separate the whole project into smaller steps that you can attack in a reasonable amount of time. In this way you can secure your survival while not losing sight of your big goal.

I also believe that a young researcher should not only stick to a single, very specialised, branch of research. It is very useful to have a broad overview of work going on in related areas (which brings us back to the subject of reading the literature), as it may sometimes happen that you get stuck in a problem that you cannot solve. Somebody who has only learnt to work on just that question then is lost, whereas someone else can easily switch to a different topic. Of course, for a student this means quite a bit of additional work and the advisor will need to understand and support such an approach but in the end it will be worthwhile.

4. Collaborations

In these days, many research projects are carried out through collaborations. The larger a project becomes, the more (wo)manpower is needed. Some scientific problems need to be tackled from various sides, and specialists on the different approaches would team up. If you are going to work on a topic that you cannot master without collaborators, how can you find out who the best collaborator will be?

Besides using your intelligence, you may want to look at different aspects of the persons you want to work with. Scientific competence is of course the primary requirement, and you will have an idea about this when knowing the literature and going to conferences, but the personality of a potential collaborator is often an important issue as well. For the special case of multisite observing campaigns, I recommend the excellent and critical article by Sterken (1988) who describes some problems that can occur in such collaborations.

Like in the "real world", there are different types of people (although I must immediately say that the variable-star community is a particularly nice one). Colleagues you may want to avoid collaborations with are egocentrics or jealous persons. Such people tend to make a group success their own and try to push others back for their own advantage.

It is often difficult to recognise colleagues of this kind before it's too late but you may be able to find some indications. There are scientists who do not cite other people's work in their papers (even if they use results of others, they may "forget" the citation), but they do cite themselves whenever possible. This way they create the impression that they are leaders in their fields. Some people criticise other's ideas (particularly those of less established people) harshly, only to use them by themselves later. Others may claim that they had certain ideas before anyone else, discouraging the person who had the original thought from pursuing it further. I again add that such cases are very rare, if at all present, in the variable-star community.

Collaborations should always be synergies, i.e. the total outcome from the collaborative work would be larger than the sum of the outcome of the individual scientists' efforts, had they worked independently. If you feel that your collaborations do not lead to a synergy or if you notice some jealousy or if you cannot work in a group, then do not collaborate. You will be happier and more efficient. There is no standard way of doing science; everyone has to find their own.

Another important point (especially in the light of what has been said above about certain personalities) is how far you can discuss your ideas with others? On the one hand, you would certainly want to find out how good your thoughts are, but on the other hand, you would not want someone else taking your ideas and results away from you.

From my own experience, I was hardly harmed by discussing my thoughts with others. The communications usually give me more input than I had before (I always leave conferences with lots of new ideas and strong motivation) and broadened my views. Therefore I suggest to discuss everything with everyone. Of course, you would want to have some sound background in order not to embarrass yourself. In addition, few people would go through all the effort of reproducing your work for taking your ideas or results away. Not discussing ideas also bears the risk of "drifting away", i.e. you may get lose yourself in paths that lead to nowhere or you would deviate to a point where you lose sight of your initial science goal. In my view, communication is always positive, and it leads to synergies.

Finally, I would like to point out that when giving you advice, more senior colleagues can be wrong as well. It is always a good thing to make up your mind and follow your own ideas if you feel they will lead you somewhere. Even if you have to withdraw some of your ideas or they are not fruitful, it is worth the effort: you will again have learnt something.

5. Career aspects

Scientific careers can, in most cases, not be planned; careers happen. Scientific qualification is not the only ingredient to be successful as a researcher on long term. Private circumstances and luck play important roles too. However, you can help yourself to a good career path, but you must also be prepared to make some sacrifices.

In our time, it is very often a requirement to have some work experience in other countries. When you graduate, you must be prepared to leave your home and to move to some foreign place. Postdoc jobs are rare, permanent jobs even rarer, and astronomy is a small community. This requires mobility at your end. It is even possible that you will have to spend a large part of the rest of your life out of your country, if you are determined to stay in astronomy.

Many students do not have a family of their own when they begin their life in science. However, as most of us do not want to spend their life in solitude, partners and even children will enter our lives. Because of the frequent need to go abroad to stay in science, conflicts between work and private life can result. This can go as far as having to make a decision about giving up a relationship or giving up science.

If you choose to give up science, you usually do not need to worry that you cannot find a job outside of science. Fortunately, a training in astronomy will also give you good skills that are required by companies. For instance, you will have mathematical and computer skills that are far above the average. Many of my former fellow students and colleagues who left astronomy have very well-paid jobs in the computer business nowadays. They are much better paid as if they had stayed in science.

A job in science is usually not one where you can make a lot of money. Consequently, astronomers are often people who do not care a lot about wealth. But they have a job they love, and I personally believe that money can never outweigh happiness.

If you are decided to stay in astronomy, it will be helpful if you made yourself irreplaceable in your area of expertise, as Margarida Cunha and Christoffer Karoff commented. This means, it would be useful if you could become a leader in your area of expertise and it would be a loss for the community if you are not given a job. What you need to do is to keep your eyes open to find your niche. In that case you would get more help from colleagues to find employment.

This point of view nicely interlocks with the previous discussion on working on subjects that matter to the community.

Another very important aspect with regard to finding a job, besides publishing, are letters of recommendation. If you apply for a postdoc or permanent position somewhere, you are usually asked to supply two or three references. This should be scientists well known in the field who know your work and who respect it to such an extent that they can recommend you warmly to a potential employer. It is again up to you to establish contacts who can serve as a reference to you. And again, this is best done by communicating, publishing, hard work and enthusiasm.

6. Summary and conclusions

Becoming a scientist is not easy. There are many challenges to be overcome and I hope I could give you some ideas of how it could work. These ranged from growing experience through initiative and enthusiasm, reading and writing, outlining research projects, finding collaborators to some prerequisites on how to increase your chances to make a career. No matter whether you are among the lucky ones or not, my main suggestions can be summarised very quickly:

Go figure. Use your intelligence. And, most importantly: have fun and enjoy!

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